# A SURVEY OF WATER QUALITY IMPACTS OF AGRICULTURAL DISCHARGES ON THE LOWER KINGS RIVER

California Regional Water Quality Control Board
Central Valley Region
3614 East Ashlan Avenue
Fresno, CA 93726

October 1990

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL VALLEY REGION

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The staff involved in the preparation of this report are:
Lonnie M. Wass, Senior Water Resource Control Engineer
Betty Yee, Water Resource Control Engineer

Special thanks to the Department of Fish and Game,
the Kings River Conservation District,
and the
Kings River Water Association

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## EXECUTIVE SUMMARY

The Lower Kings River (River) study was conducted to confirm beneficial uses, determine impacts of subsurface agricultural drainage discharges, and characterize other types of agricultural discharges.

Field investigations were conducted between November 1988 and July 1989. The period from 1987 to 1989 was a drought period and fresh water was minimal. During the sampling events, most of the River downstream of People's Weir was dry with standing water from the Crescent Headworks to Empire Weir #2 (endpoint of South Fork of the River). Thus, these field investigations are not indicative of typical conditions but do demonstrate the effects of agricultural discharges during drought or low flow conditions.

The Water Quality Control Plan for the Tulare Lake Basin (Basin Plan) contains water quality objectives. Samples show that the River is not meeting the objectives for electrical conductance and pH during low flow periods. The samples also show high boron, chloride, molybdenum and sulfate. The most severely impacted stretch is the Crescent Bypass.

Additional monitoring is recommended, particularly when the drought has ended and "normal water year" samples may be obtained. Also, individual discharges to the Crescent Bypass should be sampled to determine the effect of these discharges. Finally, a plan to correct impacts should be developed. This plan should identify corrective and preventative actions and implementing agencies.

## INTRODUCTION

The River begins in the highest elevations of the Sierra Nevada in the northeast part of the Tulare Lake Hydrologic Basin. It is dammed near Piedra in the Sierra Nevada foothills to form Pine Flat Reservoir. From the reservoir, it flows in a southwesterly direction towards historic Tulare Lake, as shown in Figures 1 and 2. About one mile east of where it meets Highway 41, the River splits into North Fork and Clarks Fork. Diversion structures are located just downstream of this split: Island Weir on North Fork and Army Weir on Clarks Fork. At the Crescent Headworks, North Fork splits into Fresno Slough (a.k.a. North Fork) and Crescent Bypass, which veers south and converges with Clarks Fork to become the South Fork. Endpoints of the River, described in the Basin Plan, are Stinson Weir on North Fork and Empire Weir #2 on South Fork. Normally, water in the Crescent Bypass will flow into South Fork. Due to the flat topography in this area, water in the South Fork and the Bypass can be forced into the Fresno Slough during heavy water years by pumping at the Crescent Headworks.

This study was conducted to gather water quality data on the River so that policy decisions may be made to mitigate impacts to beneficial uses due to subsurface

agricultural drainage discharges, as identified in the 1987 Triennial Review. The study area, shown with sampling stations on Figure 2, is bounded by People's Weir (Station 1) on the upstream side and the endpoints (Stations 4 and 16) on the downstream side. There are no point source discharges in the study area. Non-point source influences are mainly from agricultural return flows, both surface and subsurface. Primary actions proposed in the Triennial Review Workplan were to verify the beneficial uses and conduct field investigations of the Lower Kings River to document water quality and potential impacts from subsurface agricultural drainage discharges. A concurrent, comprehensive investigation of the discharges to South Fork was also part of the proposed primary action.

In order to efficiently utilize staff and resources, the study was broken into phases. The first phase of the study, conducted from November 1988 to July 1989, consisted of gathering available information to verify existing beneficial uses, and field investigations to determine water quality and potential impacts to the beneficial uses due to agricultural discharges. Data from the field investigations will be used to target the most heavily impacted stretches for closer examination.

## BENEFICIAL USES AND WATER QUALITY OBJECTIVES

Beneficial uses within the study area, as designated in the Basin Plan, include agricultural supply (irrigation and stock watering), water contact recreation, non-contact water recreation, warm fresh water habitat, wildlife habitat, and ground water recharge.

Currently, the entire stretch from Pine Flat Dam to the endpoints is used for irrigation by intermittent diversions. Most irrigation water releases occur from May through September each year, with small releases during the rest of the year. An agreement between the Kings River Water Association and the Department of Fish and Game provides minimum releases of 25 cfs from Pine Flat to ensure maintenance of non-agricultural beneficial uses.

Where water was available in the River during staff field observations, stock watering and grazing occurred on the banks, warm fresh water habitat was supported, and people continued to fish and wade. Wildlife habitat continues to be a beneficial use, although the removal of riparian vegetation from the top of the banks have diminished the habitat.

The Basin Plan's water quality objective for maximum electrical conductance is 300 micromhos/cm downstream of Kingsburg (People's Weir or Station 1) during irrigation deliveries. During periods of low flow, maximum electrical conductance is 400 micromhos/cm downstream of Kingsburg and 600 micromhos/cm downstream of Island Weir and Army Weir (Station 3). No exceptions are described for periods of extreme conditions such as droughts.

The water quality objective for minimum dissolved oxygen is 7 mg/l from Kingsburg to Island Weir and Army Weir. From Island Weir and Army Weir to the endpoints, the minimum dissolved oxygen objective is 5 mg/l.

Other applicable numeric water quality objectives are pH (shall remain between 6.5 and 8.3), fecal coliform (shall not exceed a geometric mean of 200/100 ml for at least five samples taken over a 30 day period), and un-ionized ammonia (shall not exceed 0.025 mg/l).

General applicable narrative objectives are that waters shall not be polluted and nuisance conditions shall not be created.

An amendment to the Basin Plan for agricultural subsurface drainage, Resolution No. 83-104, states that waste discharge requirements are waived for "interim" surface water discharges which do not exceed 1,000 micromhos/cm electrical conductance, 175 mg/l chlorides and 1 mg/l boron, and which do not cause water quality objectives set forth in the Basin Plan to be exceeded.

The State Water Resources Control Board projects adoption of new water quality standards for all inland surface waters in California in December 1990. Standards have been proposed for metals, organics and pesticides.

BACKGROUND

The River flow fluctuates with climate, but dams now moderate the flows. The last four years have been drought years and conditions on the River were not indicative of normal water years. The length and severity of this drought (1986 to 1990) is not typical as a similar period has only occurred once (from 1927 to 1931) in the 93-year recorded history of the River.

The River has not flowed into North Fork since 1987, or into South Fork since 1988. In 1989, all of the water released from Pine Flat Reservoir during the irrigation season was diverted at the Lemoore Weir (Station 2, located two miles southwest of the community of Laton) to the Lemoore Canal. During non-irrigation delivery periods, the River has not flowed any distance past People's Weir. There was only standing water downstream of the Crescent Headworks (Station 8).

Westlake Farms, located on both sides of South Fork from Empire Weir #1 (Station 14) to Empire Weir #2 (Station 16), has water rights to irrigate lands east of the River. Due to the nonflow conditions, Westlake has used the South Fork to transfer well water from the west side to the east side of the River. Due to the prolonged drought, several irrigation districts stored well water in the South Fork for the 1990 irrigation season.

## PREVIOUS INFORMATION

A 208 study was conducted in 1983 to: (1) define the deterioration of water quality in the South Fork; and (2) develop a program to prevent contamination of the South Fork by unregulated agricultural drainage and return flows of poor quality. The study found that agricultural discharges to the South Fork contained high levels of boron, chloride, conductivity, and sodium. Recommended measures to prevent contamination of the South Fork were to establish water quality standards, to construct structures to prevent seepage from irrigated lands from entering the River and seepage from the River from raising ground water levels in surrounding land, and to develop a monitoring program.

The 1987 triennial review for the Tulare Lake Basin recognized the high salinity problem in South Fork and prescribed additional studies to assess the impact of subsurface agricultural drainage discharges on the River.

The 1989 Water Quality Assessment listed the River downstream of People's Weir as a Water Quality Limited Segment due to high salt concentrations.

As part of the State Board's ongoing Toxic Substances Monitoring Program, fish from the South Fork were sampled in 1986. Results show elevated levels of copper, arsenic, toxaphene, and group A pesticides in the liver and filet of white bass \1.

Since 1976, the Kings River Conservation District (KRCD) has been sampling the River and discharges to it for flow, pH, conductivity, and temperature. Because of equipment limitations, recent conductivity data supplied by KRCD are suspect and not considered in this report.

## CURRENT STUDY

A total of 16 sampling stations were chosen. These stations are shown on Figure 2 and listed in Table 1. Samples were analyzed for selected minerals and trace elements and results are tabulated on Table 2.

Sampling began in November 1988. Two other sampling events were conducted in February 1989 and July 1989. Results are not indicative of normal river conditions because of the prolonged drought. November 1988 and February 1989 were low flow periods. The Lemoore Weir and all locations on North and Clarks forks were dry. July 1989 was an irrigation delivery period; however, all water was diverted at the Lemoore Weir (Station 2) into the Lemoore Irrigation Canal so North and Clarks forks were dry.

Samples were taken in a triple-rinsed bucket from the approximate middle of the River and then transferred to acid washed bottles. At least 10% of the samples were duplicates.

## RESULTS AND DISCUSSION

Natural or background River water, as characterized at People's Weir, has low conductivity, salinity, and trace elements, with a sulfates to chlorides ratio of 0.74. Water downstream of the Crescent Headworks (Station 8) has high electrical conductivity levels, moderate-to-high minerals, and varying concentrations of trace elements. The sulfates to chlorides ratio ranges from 2.2 to 4.8, which indicates that the water is dominated by sulfates. In comparison, ocean water (chlorides dominated) has a ratio of about 0.1 and typical agricultural subsurface drainage, as measured in the Stone Land Co. evaporation basins, has a ratio of about 5.3 \2.

The results show that electrical conductivity from the Crescent Headworks (Station 8) to Empire Weir #2 (Station 14) ranged from 600 micromhos/cm to almost 20,000 micromhos/cm. The highest conductivity levels (2600 to 19,800 micromhos/cm) were found at Crescent Bypass/Lacey Ave (Station 11); the lowest levels (600 to 1400 micromhos/cm) were found at the Jackson Avenue bridge (Station 13) and Empire Weir #1 (Station 14). The Basin Plan objective for electrical conductance is 600 micromhos/cm downstream of the Island Weir (Station 3).

Results also show that pH levels from People's Weir to the endpoints are higher than the Basin Plan objective of 6.5 to 8.3. Elevated pH levels downstream of the Crescent Headworks may not be due to discharges since background pH, as measured at People's Weir, is already elevated. Further determinations regarding the pH of the River are outside the scope of this study.

Boron levels downstream of the Crescent Headworks (Station 8) typically range from 0.29 to 2.8 mg/l except at Crescent Bypass/Lacey Ave (Station 11) where the levels have reached 15 mg/l. The agricultural water quality goal for boron is 0.8 mg/l and the recommended level to protect all aquatic life is 0.55 mg/l \3. Boron concentrations exceed these levels at almost all points downstream of the Crescent Headworks. The Basin Plan contains no water quality objective for boron but does include an amendment, Resolution No. 83-104, which specifies that boron levels in agricultural waste discharges to surface waters should not be over 1 mg/l. It is likely that discharges in this stretch are violating Resolution No. 83-104. Investigation of these discharges is necessary.

Sulfate levels downstream of the Crescent Headworks (Station 8) vary from 220 to 11,000 mg/l, while chloride levels vary with the sulfates from 55 to 1800 mg/l.

Trace element concentrations are typically low in the River. Chromium, copper, lead, nickel, and zinc values are less than or slightly above detection limits. Selenium was over 1 ug/l at Empire Weir #2 (Station 16), Grangeville Avenue (Station 10) and Laurel Avenue (Station 15), but less than 1 ug/l at all other sample points. Arsenic varied from none detected to a high of 17 ug/l at Laurel Avenue.

Molybdenum was over 10 ug/l at all points downstream of Crescent Headworks with maximum concentrations of over 100 ug/l at Crescent Headworks (Station 8) and Crescent Bypass/Lacey Ave (Station 11). Compared to background water, selenium, arsenic and molybdenum are high, but only molybdenum is high enough to exceed water quality criteria. The criterion for agricultural supply is 10 ug/l \4 and the recommended level to protect all aquatic life is 19 ug/l. \3

Some beneficial uses downstream of the Crescent Headworks (Station 8) have probably been impaired due to the high salinity and lack of water. It is unlikely that the River could be used for irrigation due to the minimal flows and the large amount of boron, salts, and molybdenum.

Based on the water quality criteria, warm fresh water habitat may be affected due to high boron and molybdenum. However, the criteria is based on cold water species which are typically more sensitive than warm water species. Site-specific objectives for the protection of aquatic life, based on historical species, is necessary to determine if any impairments to warm fresh water habitat have occurred. If the warm fresh water habitat beneficial use has been impacted, then non-contact recreation (fishing) would also be impacted.

Consultations with Department of Fish and Game (DFG) indicate fish kills have occurred. DFG believes the kills were due to oxygen sags in the River. No data is available to corroborate the cause of the fish kills, but it is likely this problem would be alleviated if the fresh water flows were greater.

The ground water recharge beneficial use downstream of the Crescent Headworks (Station 8) has probably also been impaired. The River channel is sandy and highly permeable and recharge with saline waters is probably occurring.

The Stone Land Co. evaporation basins are located adjacent to the Crescent Bypass/Lacey Ave (Station 11) sampling point. Electrical conductance in the basins range from 27,350 to 111,000 micromhos/cm \2. Sulfate and chloride concentrations in the basins are extremely high. Inflow to the basins has a sulfates to chlorides ratio of about 6.9, but this ratio drops to about 5.3 as the salts concentrate in the basins and the highly concentrated sulfates precipitate out of solution. Boron levels in the basins range from 38 to 340 mg/l.

Information provided by KRCD indicates that discharges at this location are tailwater, stormwater, river seepage, and tile drainage. Average conductivity of these discharges is less than 10,000 micromhos/cm, but greater than the 1,000 micromhos/cm specified in the Basin Plan Amendment, Resolution No. 83-104, for waiver of waste discharge requirements.

The poor quality at Crescent Bypass/Lacey Ave (Station 11) may be due to seepage from the nearby evaporation basins and/or agricultural discharges in combination

with concentration of salts by evaporation within the river channel. The source of the high salinity may be determined more accurately with a detailed analysis of the inflows in this stretch.

The stretch from Jackson Avenue (Station 13) to Empire Weir #1 (Station 14) has relatively good quality water with electrical conductivity ranging from 600 to 1400 micromhos/cm. Discharges to this stretch contain mainly tailwater and irrigation return flows with electrical conductivity ranging from less than 1,000 to greater than 20,000 micromhos/cm. Also, the short term addition of well water by farmers in the vicinity of Empire Weir #1 may be improving the quality of the water in this stretch.

## CONCLUSIONS AND RECOMMENDATIONS

Sampling indicates that the water in the River was not meeting water quality objectives for electrical conductance and pH during the sampling period and probably not supporting the beneficial uses due to the lack of water and high electrical conductance, boron, chloride, molybdenum, and sulfate. Beneficial uses which may be impaired include agricultural supply, non-contact recreation, warm fresh water habitat, and ground water recharge. The causes of these impairments are due to several factors, chief among them the lack of fresh water to flush out the River. Contributing to these impairments are the discharges of agricultural wastewater with high salinity and trace elements.

Due to four consecutive years of drought, the results demonstrate conditions during a period of extreme dryness and do not represent normal conditions. During this sampling period, the River was not flowing and was basically a long and narrow lake containing a substantial quantity of agricultural discharges of varying quality. The 1989 Water Quality Assessment listed the River downstream of People's Weir as a Water Quality Limited Segment. Information gathered during this phase of the investigation confirms this listing. It is recommended that the Kings River downstream of People's Weir be designated in the Basin Plan as a Water Quality Limited Segment.

Additional studies should be conducted to determine specific impacts to beneficial uses. The River quality should be compared with agricultural water quality objectives to determine the suitability of the River water as agricultural supply. Standard biotoxicity tests should be performed with River water to determine potential impacts to fish habitats.

The next phase of this study should be to conduct chemical analyses of various discharges to determine the extent of impact each type of discharge has on the River. In order to adequately characterize the inflows, discharges should be sampled during the irrigation season, the period of greatest discharge. A plan to correct any impacts should be developed. This plan should identify corrective and preventative actions

and all potential implementing agencies. The Central Valley Regional Board requested Basin plan update funds from the State Water Resources Control Board to examine the Lower Kings River and the discharges into it, develop site-specific water quality objectives, identify and quantify sources of impacts, and develop an implementation plan, as described above, to correct controllable impacts on water quality and meet water quality objectives.

Additional samples are necessary to characterize normal river conditions when the River is flowing and existing water has been flushed out of the system.

These preliminary results are helpful as a tool to further define the study. Sampling on a semi-annual basis should be continued and the sampled constituents should be expanded to include anions, dissolved oxygen, coliform organisms, un-ionized ammonia, fertilizers and pesticides.

1. Rasmussen, D., "Toxic Substances Monitoring Program, 1986", State Water Resources Control Board, May 1988.

2. Stone Land Co. evaporation basin data from Regional Board files.

3. State Water Resources Control Board, 1988, "Water Quality Criteria for Selenium and Other Trace Elements for the Protection of Aquatic Life and Its Uses in the San Joaquin Valley", Final Report

4. National Academy of Sciences and National Academy of Engineering, "Water Quality Criteria", U. S. Government Printing Office, Washington, D. C.

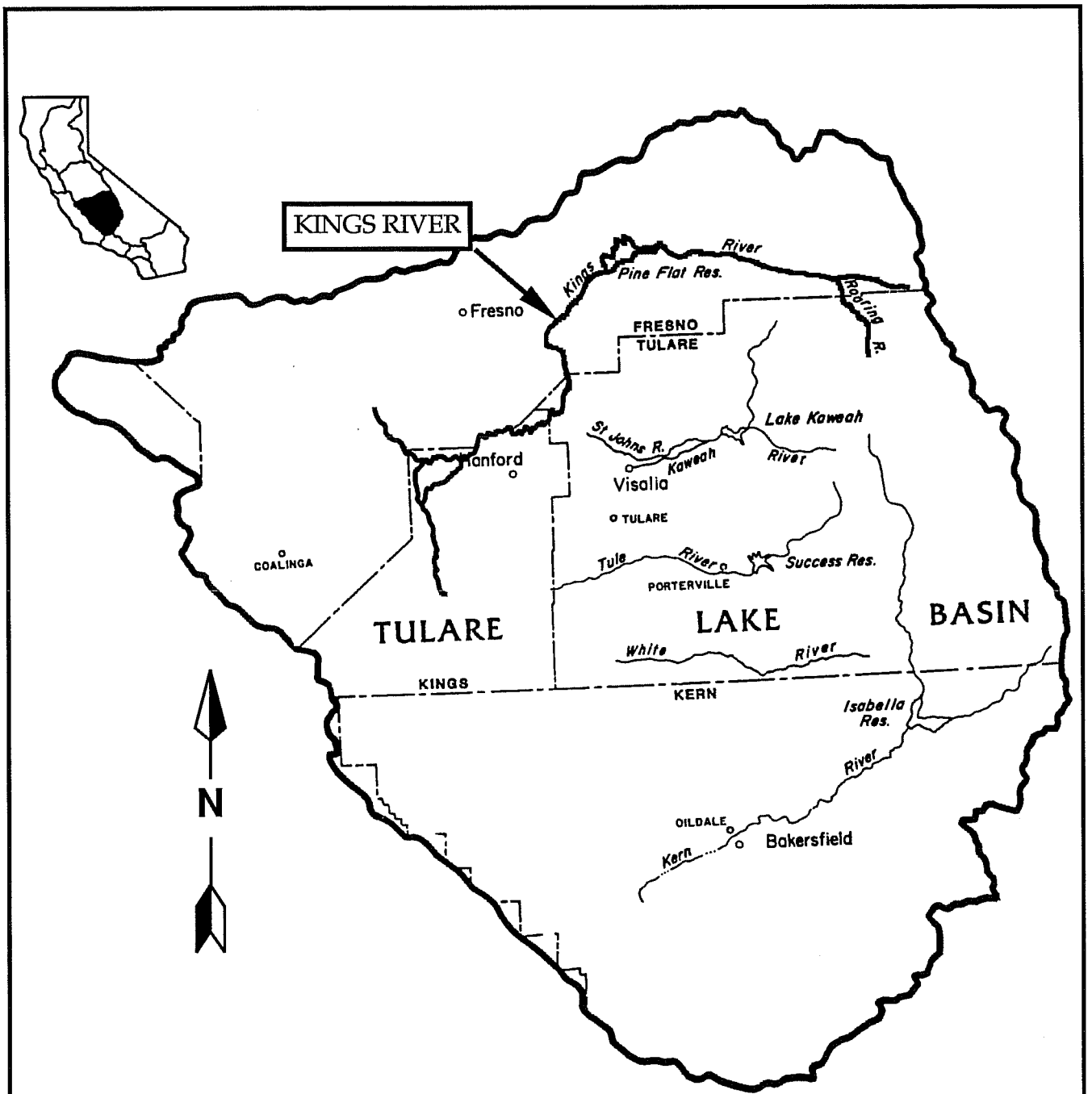


FIGURE 1

**KINGS RIVER**
FRESNO, KINGS, AND TULARE COUNTIES

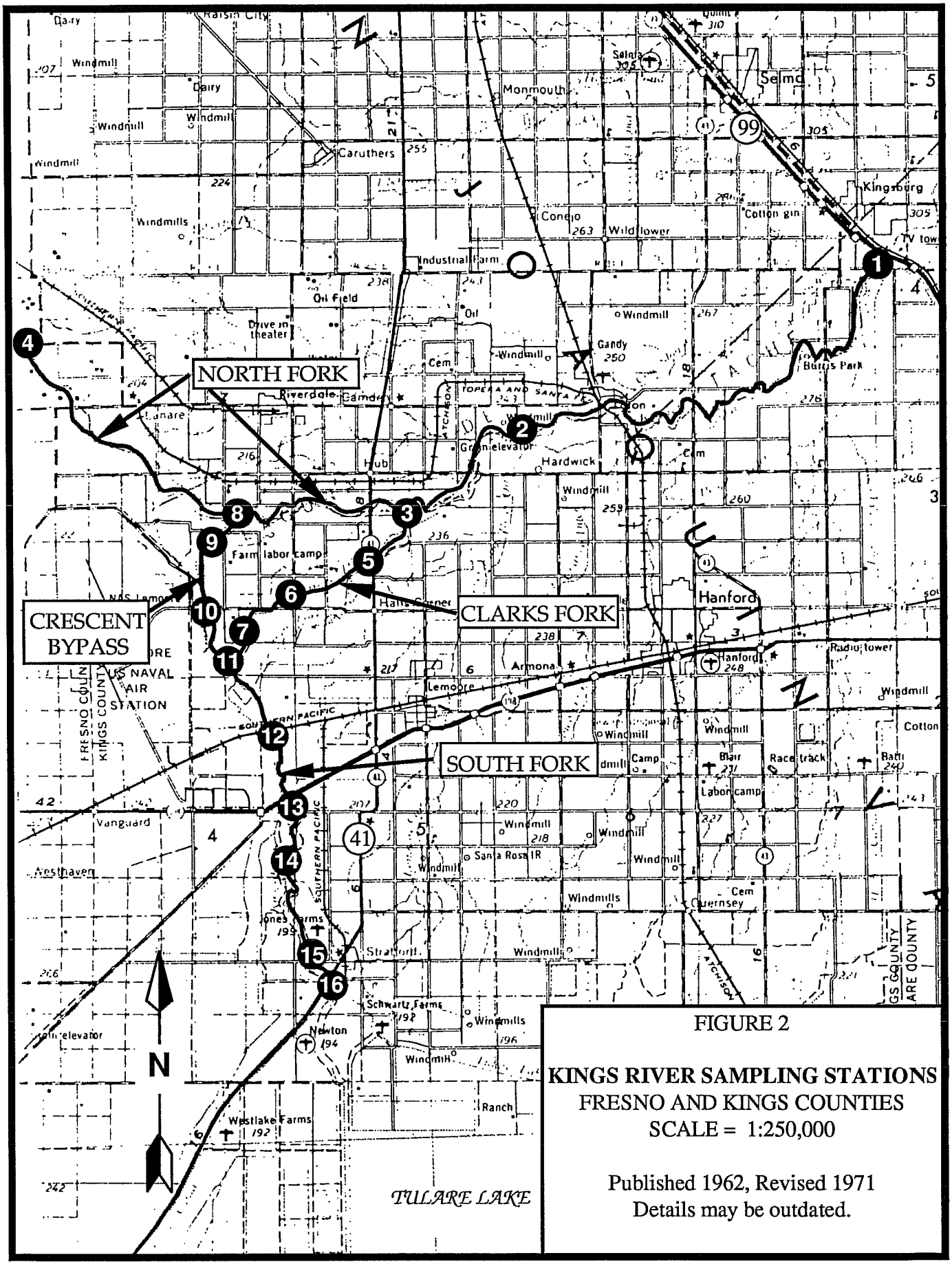


FIGURE 2

**KINGS RIVER SAMPLING STATIONS**
FRESNO AND KINGS COUNTIES
SCALE = 1:250,000

Published 1962, Revised 1971
Details may be outdated.

TABLE 1
KINGS RIVER SAMPLING STATIONS

| Station Code | Station Location | Kings River Conservation District Station Code |
|---|---|---|
| 1 | People's Weir Gaging Station | 0.30 |
| 2 | Lemoore Weir Gaging Station | 0.35 |
| | NORTH FORK: | |
| 3 | Island Weir Gaging Station and Army Weir | 66.90 |
| 4 | Stinson Weir | 42.50 |
| | CLARKS FORK: | |
| 5 | Highway 41 Bridge | 3.50 |
| 6 | 22nd Avenue Bridge | 4.50 |
| 7 | Lacey Avenue Bridge | 5.50 |
| | CRESCENT BYPASS: | |
| 8 | Crescent Bypass Headworks | 61.70 |
| 9 | 24th Avenue Bridge | 34.50 |
| 10 | Grangeville | 32.50 |
| 11 | Lacey Avenue (Downstream of pump back) | 31.50 |
| | SOUTH FORK: | |
| 12 | Railroad Bridge | 9.50 |
| 13 | Jackson Avenue Bridge | 13.10 |
| 14 | Empire Weir #1 | 13.50 |
| 15 | Laurel Avenue | XX.XX [1] |
| 16 | Empire Weir #2 | 17.60 |

[1] Not a sampling point for the Kings River Conservation District

TABLE 2: KINGS RIVER SAMPLING DATA

| | | umhos/cm | | (mg /l) | | | | | | | (ug /l) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Location | Date | EC | pH | HCO3 | B | 'CO3 | Cl | SO4 | T Alk | SO4/Cl Ratio* | As | Cr | Cu | Pb | Mo | Ni | Se | Zn |
| 1 People's Weir | Nov-88 | 149 | 8.3 | -- | 0.03 | -- | 4 | 9 | -- | 1.66 | <4 | 1 | 2 | <5 | 3 | <5 | 0.3 | 1 |
| | Feb-89 | 199 | 8.9 | 76 | 0.02 | <1 | 8 | 15 | 76 | 1.39 | <4 | <1 | 2 | <5 | -- | <5 | 0.2 | 3 |
| | Jul-89 | 36 | 7.3 | 18 | <0.02 | <2 | 3 | 3 | 18 | 0.74 | <2 | <1 | 1 | <5 | 3 | <5 | 0.2 | <5 |
| 2 Lemoore Weir | Nov-88 | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY |
| | Feb-89 | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY | | DRY | DRY | DRY | DRY | DRY | DRY | DRY | DRY |
| | Jul-89 | 35 | 7.5 | 15 | <0.02 | <2 | 3 | 3 | 15 | 0.74 | <2 | <1 | 2 | <5 | 3 | <5 | 0.3 | <5 |
| 8 Crescent | Nov-88 | 4880 | 8.6 | -- | 2.8 | -- | 330 | 1800 | -- | 4.03 | 4 | 5 | 9 | <5 | 130 | 8 | 1 | 18 |
| Headworks | Feb-89 | 3190 | -- | 120 | 1.6 | <1 | 260 | 1000 | 120 | 2.84 | <4 | 3 | 2 | <5 | -- | 6 | 0.5 | 8 |
| | Jul-89 | 3370 | 9 | 100 | 2.7 | <2 | 320 | 1200 | 100 | 2.77 | 4 | 1 | 3 | <5 | 104 | 5 | 0.5 | 14 |
| 9 CB/24th ave. | Nov-88 | -- | -- | -- | -- | -- | -- | -- | -- | | -- | -- | -- | -- | -- | -- | -- | -- |
| | Feb-89 | 1790 | -- | -- | 0.81 | -- | -- | -- | -- | | <4 | -- | -- | -- | 20 | -- | 0.5 | -- |
| | Jul-89 | 1985 | 9.1 | 120 | 1.4 | <2 | 190 | 570 | 120 | 2.22 | 5 | 3 | 3 | <5 | 53 | 7 | 0.5 | 12 |
| 10 CB/Grangeville | Nov-88 | 2700 | 8.3 | -- | 1.2 | -- | -- | -- | -- | | <4 | -- | -- | -- | 19 | -- | 0.7 | -- |
| | Feb-89 | 2900 | 8.7 | -- | 1.4 | -- | -- | -- | -- | | <4 | -- | -- | -- | 29 | -- | 1.3 | -- |
| | Jul-89 | 3100 | 9.4 | 89 | 1.7 | <2 | 255 | 1200 | 89 | 3.48 | 7 | 9 | 5 | <5 | 28 | 16 | 0.8 | 23 |
| 11 CB/Lacey Ave | Nov-88 | 2620 | 8.8 | -- | 1.4 | -- | -- | -- | -- | | <4 | -- | -- | -- | 46 | -- | 0.7 | -- |
| | Feb-89 | 8950 | 9.2 | -- | 5.1 | -- | -- | -- | -- | | <4 | -- | -- | -- | 55 | -- | 0.4 | -- |
| | Jul-89 | 19810 | 9.5 | 150 | 15 | 55 | 1800 | 11000 | 205 | 4.52 | 5 | 4 | <5 | <5 | 154 | 8 | 0.4 | 10 |
| 12 Railroad Bridge | Nov-88 | 1070 | 8.2 | -- | 0.37 | -- | 64 | 270 | -- | 3.12 | <4 | 1 | 2 | <5 | 10 | <5 | 0.4 | 3 |
| | Feb-89 | 1340 | 8 | 100 | 0.44 | <1 | 87 | 390 | 100 | 3.32 | <4 | 1 | 2 | <5 | -- | <5 | 0.3 | 5 |
| | Jul-89 | 2760 | 8.6 | 190 | 1.8 | 24 | 170 | 1100 | 214 | 4.79 | 9 | <1 | 2 | <5 | 30 | <5 | 0.3 | <5 |
| 13 Jackson Ave | Nov-88 | 675 | -- | -- | 0.3 | -- | -- | -- | -- | | <4 | -- | -- | -- | 10 | -- | 0.5 | -- |
| | Feb-89 | 1380 | -- | -- | 0.67 | -- | -- | -- | -- | | <4 | -- | -- | -- | 14 | -- | 0.6 | -- |
| | Jul-89 | 768 | 8.5 | 73 | 0.47 | <2 | 55 | 240 | 73 | 3.23 | 3 | 2 | 3 | <5 | 13 | <5 | 0.4 | 13 |
| 14 Empire Weir #1 | Nov-88 | 624 | 8.1 | -- | 0.29 | -- | -- | -- | -- | | <4 | -- | -- | -- | 10 | -- | 0.5 | -- |
| | Feb-89 | 1070 | 8.1 | -- | 0.49 | -- | -- | -- | -- | | 5 | -- | -- | -- | 12 | -- | 0.4 | -- |
| | Jul-89 | 789 | 7.9 | 96 | 0.56 | 3 | 57 | 220 | 99 | 2.85 | 5 | 7 | 6 | <5 | 14 | 10 | 0.4 | 24 |
| 15 Laurel Ave. | Nov-88 | 1360 | 8.5 | -- | 0.5 | -- | -- | -- | -- | | <4 | -- | -- | -- | 18 | -- | 0.8 | -- |
| | Feb-89 | 2890 | -- | -- | 1 | -- | -- | -- | -- | | <4 | -- | -- | -- | 58 | -- | 1.7 | -- |
| | Jul-89 | 2580 | 9.3 | 130 | 1.4 | 12 | 210 | 960 | 142 | 3.38 | 17 | 2 | 3 | <5 | 62 | <5 | 0.6 | 9 |
| 16 Empire Weir #2 | Nov-88 | 1220 | 8.5 | -- | 0.46 | -- | 71 | 360 | -- | 3.75 | <4 | 2 | 2 | <5 | 14 | <5 | 0.9 | 5 |
| | Feb-89 | 2430 | 9 | 70 | 0.86 | <1 | 190 | 820 | 70 | 3.19 | <4 | 1 | 2 | <5 | -- | <5 | 1.3 | 4 |
| | Jul-89 | 1090 | 8.7 | 97 | 0.63 | 3 | 90 | 310 | 100 | 2.55 | 8 | 5 | 5 | <5 | 24 | 8 | 0.6 | 18 |

NOTE: -- No data available

BY:8/23/90

* SO4/Cl Ratio determined by comparison of milliequivalents.